Algebra II

Content Standards

2016

Compiled using the Arkansas Mathematics Standards

Course Title:	Algebra II
Course/Unit Credit:	1
Course Number:	432000
Teacher Licensure:	Please refer to the Course Code Management System (https://adedata.arkansas.gov/ccms/) for the most current licensure codes.
Grades:	9-12
Prerequisite:	Algebra I or Algebra A/B

Course Description: "Building on their work with linear, quadratic, and exponential functions, students extend their repertoire of functions to include polynomial, rational, and radical functions. Students work closely with the expressions that define the functions, and continue to expand and hone their abilities to model situations and to solve equations, including solving quadratic equations over the set of complex numbers and solving exponential equations using the properties of logarithms.

This document was created to delineate the standards for this course in a format familiar to the educators of Arkansas. For the state-provided Algebra A/B, Algebra I, Geometry A/B, Geometry, and Algebra II documents, the language and structure of the Arkansas Mathematics Standards (AMS) have been maintained. The following information is helpful to correctly read and understand this document.

> "**Standards** define what students should understand and be able to do.
> **Clusters** are groups of related standards. Note that standards from different clusters may sometimes be closely related, because mathematics is a connected subject.
> **Domains** are larger groups of related standards. Standards from different domains may sometimes be closely related." - http://www.corestandards.org/

Standards do not dictate curriculum or teaching methods. For example, just because topic A appears before topic B in the standards for a given grade, it does not necessarily mean that topic A must be taught before topic B. A teacher might prefer to teach topic B before topic A, or might choose to highlight connections by teaching topic A and topic B at the same time. Or, a teacher might prefer to teach a topic of his or her own choosing that leads, as a byproduct, to students reaching the standards for topics A and B.

The standards in this document appear exactly as written in the ASM. Italicized portions of the standards offer clarification. The Plus Standards (+) from the Arkansas Mathematics Standards may be incorporated into the curriculum to adequately prepare students for more rigorous courses (e.g., Advanced Placement, International Baccalaureate, or concurrent credit courses).

Algebra II

Domain	Cluster	Course Emphases
The Real Number System		
	1. Extend the properties of exponents to rational exponents	Major
	2. Use properties of rational and irrational numbers	
Quantities		
	3. Reason quantitatively and use units to solve problems	Supporting
The Complex Number System		
	4. Perform arithmetic operations with complex numbers	Additional
	5. Use complex numbers in polynomial identities and equations	Additional
Vector and Matrix Quantities		
	6. Perform operations on matrices and use matrices in applications	
Seeing Structure in Expressions		
	7. Interpret the structure of expressions	Major
	8. Write expressions in equivalent forms to solve problems	Major
Arithmetic with Polynomials and Rational Expressions		
	9. Perform arithmetic operations on polynomials	
	10. Understand the relationship between zeros and factors of polynomials	Major
	11. Use polynomial identities to solve problems	Additional
	12. Rewrite rational expressions	Supporting
Creating Equations		
	13. Create equations that describe numbers or relationships	Supporting
Reasoning with Equations and Inequalities		
	14. Understand solving equations as a process of reasoning and explain the reasoning	Major
	15. Solve equations and inequalities in one variable	Supporting
	16. Solve systems of equations and inequalities graphically.	Additional
	17. Solve systems of equations	Major
Interpreting Functions		
	18. Understand the concept of a function and use function notation	Supporting
	19. Interpret functions that arise in applications in terms of the context	Major
	20. Analyze functions using different representations	Supporting
Building Functions		
	21. Build a function that models a relationship between two quantities	Major
	22. Build new functions from existing functions	Additional
Linear, Quadratic, and Exponential Models		
	23. Construct and compare linear, quadratic, and exponential models and solve problems	Supporting

Domain	Cluster	Course Emphases
Interpreting Categorical and Quantitative Data		
	24. Summarize, represent, and interpret data on a single count or measurement variable	Additional
	25. Summarize, represent, and interpret data on two categorical and quantitative variables	Supporting
Making Inferences and Justifying Conclusions		
	26. Understand and evaluate random processes underlying statistical experiments	Supporting
	27. Make inferences and justify conclusions from sample surveys, experiments and observational studies	Major

Domain: The Real Number System

Cluster(s): 1. Extend the properties of exponents to rational exponents
2. Use properties of rational and irrational numbers

HSN.RN.A.1	1	Explain how extending the properties of integer exponents to rational exponents provides an alternative notation for radicals. For example: We define $5^{4/3}$ to be the cube root of 5^4 because we want $(5^{4/3})^{3/4} = 5$ to hold.	Major
HSN.RN.A.2	1	Rewrite expressions involving radicals and rational exponents using the properties of exponents.	Major
HSN.RN.B.4	2	• Simplify radical expressions • Perform operations (add, subtract, multiply, and divide) with radical expressions • Rationalize denominators and/or numerators	Supporting

Domain: Quantities

Cluster(s): 3. Reason quantitatively and use units to solve problems

HSN.Q.A.2	3	Define appropriate quantities for the purpose of descriptive modeling. (I.E., Use units appropriate to the problem being solved.)	Supporting

Key:

ASM Domain and Standard #	ASM Cluster	ASM Standard	Course Emphases (Category)

Domain: The Complex Number System

Cluster(s): 4. Perform arithmetic operations with complex numbers

5. Use complex numbers in polynomial identities and equations

HSN.CN.A.1	4	Know there is a complex number i such that $i^2 = -1$, and every complex number has the form $a + bi$ with a and b real.	Additional
HSN.CN.A.2	4	Use the relation $i^2 = -1$ and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers.	Additional
HSN.CN.A.3	4	• Find the conjugate of a complex number. • Use conjugates to find quotients of complex numbers.	Supporting
HSN.CN.C.7	5	Solve quadratic equations with real coefficients that have real or complex solutions.	Additional
HSN.CN.C.8	5	(+) Extend polynomial identities to the complex numbers. *For example: Rewrite $x^2 + 4$ as $(x + 2i)(x - 2i)$.*	Additional
HSN.CN.C.9	5	• (+) Know the Fundamental Theorem of Algebra • (+) Show that it is true for quadratic polynomials.	Major

Domain: Vector and Matrix Quantities

Cluster(s): 6. Perform operations on matrices and use matrices in applications

HSN.VM.C.6	6	(+) Use matrices to represent and manipulate data (e.g., to represent payoffs or incidence relationships in a network).	Additional
HSN.VM.C.7	6	(+) Multiply matrices by scalars to produce new matrices (e.g., as when all of the payoffs in a game are doubled).	Additional
HSN.VM.C.8	6	(+) Add, subtract, and multiply matrices of appropriate dimensions.	Additional
HSN.VM.C.9	6	(+) Understand that, unlike multiplication of numbers, matrix multiplication for square matrices is not a commutative operation, but still satisfies the associative and distributive properties.	Additional
HSN.VM.C.10	6	Understand that: • (+) The zero and identity matrices play a role in matrix addition and multiplication similar to the role of 0 and 1 in the real numbers. • (+)The determinant of a square matrix is nonzero if and only if the matrix has a multiplicative inverse.	Additional
HSN.VM.C.12	6	(+) Work with 2 × 2 matrices as transformations of the plane, and interpret the absolute value of the determinant in terms of area.	Additional

Key:

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Domain: Seeing Structure in Expressions
Cluster(s): 7. Interpret the structure of expressions
8. Write expressions in equivalent forms to solve problems

HSA.SSE.A.1	7	Interpret expressions that represent a quantity in terms of its context. • Interpret parts of an expression using appropriate vocabulary, such as terms, factors, and coefficients. • Interpret complicated expressions by viewing one or more of their parts as a single entity. *For example: Interpret* $P(1 \pm r)^n$ *as the product of P and a factor not depending on P*.	Major
HSA.SSE.A.2	7	Use the structure of an expression to identify ways to rewrite it. *For example: See that (x + 3)(x + 3) is the same as* $(x + 3)^2$ *OR* $x^4 - y^4$ *as* $(x^2)^2 - (y^2)^2$*, thus recognizing it as a difference of squares that can be factored as* $(x^2 - y^2)(x^2 + y^2)$.	Major
HSA.SSE.B.3	8	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. • Factor a quadratic expression to reveal the zeros of the function it defines. Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines. Note: Students should be able to identify and use various forms of a quadratic expression to solve problems. o Standard Form: $ax + bx + c$ o Factored Form: $a(x - r_1)(x - r_2)$ o Vertex Form: $a\ (x - h\ ) + k$ • Use the properties of exponents to transform expressions for exponential functions. *For example: The expression* 1.15^t *can be rewritten as* $(1.15^{1/12})^{12t} \approx 1.012^{12t}$ *to reveal the approximate equivalent monthly interest rate if the annual rate is 15%*.	Major

Key:

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Key:

ASM Domain and Standard #	ASM Cluster	ASM Standard	Course Emphases (Category)

Domain: Arithmetic with Polynomials and Rational Expressions
Cluster(s): 9. Perform arithmetic operations on polynomials
10. Understand the relationship between zeros and factors of polynomials
11. Use polynomial identities to solve problems
12. Rewrite rational expressions

HSA.APR.A.1	9	• Add, subtract, and multiply polynomials • Understand that polynomials, like the integers, are **closed** under addition, subtraction, and multiplication Note: If p and q are polynomials p + q, p – q, and pq are also polynomials	Major
HSA.APR.B.2	10	Know and apply the Factor and Remainder Theorems: For a polynomial $p(x)$ and a number a, the remainder on division by $x - a$ is $p(a)$, so $p(a) = 0$ if and only if $(x - a)$ is a factor of $p(x)$.	Major
HSA.APR.B.3	10	• Identify zeros of polynomials when suitable factorizations are available • Use the zeros to construct a rough graph of the function defined by the polynomial. Note: Algebra I is limited to the use of quadratics.	Major
HSA.APR.C.4	11	Prove polynomial identities and use them to describe numerical relationships. *Note: Examples of Polynomial Identities may include but are not limited to the following:* • $(a + b)^2 = a^2 + 2ab + b^2$ *(Algebra 1)* • $a^2 – b^2 = (a – b)(a + b)$ *(Algebra 1)* $(x^2 + y^2)^2 = (x^2 - y^2)^2 + (2xy)^2$ *can be used to generate Pythagorean triples (Algebra 2).*	Additional
HSA.APR.D.6	12	Rewrite simple rational expressions in different forms; write $^{a(x)}/_{b(x)}$ in the form $q(x) + {}^{r(x)}/_{b(x)}$, (where $a(x)$ is the dividend, $b(x)$ is the divisor, $q(x)$ is the quotient, and $r(x)$ is the remainder) are polynomials with the degree of $r(x)$ less than the degree of $b(x)$, using inspection, long division, or, for the more complicated examples, a computer algebra system. *For example:* $\frac{3x^3-5x^2+10x-3}{3x+1} = x^2-2x+4+\frac{-7}{3x+1}$ Note: Students should understand that this method of dividing polynomials can be used for any polynomial expression, but that synthetic division should only be used when the divisor is a first-degree polynomial. Students should also recognize that when using synthetic division with a first-degree polynomial divisor that has a leading	Supporting

Key:

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		coefficient other than one, (such as $3x + 1$, where $x = -1/3$ is the "synthetic divisor" as in the example above), that the denominator of the "synthetic divisor" must be factored out of the quotient and multiplied by the divisor after the synthetic division has taken place.	
HSA.APR.D.7	12	• Add, subtract, multiply, and divide by nonzero rational expressions • Understand that rational expressions, like the integers, are closed under addition, subtraction, and multiplication	Supporting

Domain: Creating Equations
Cluster(s): 13. Create equations that describe numbers or relationships

HSA.CED.A.1	13	Create equations and inequalities in one variable and use them to solve problems. Note: *Including but not limited to equations arising from:* • *Linear functions* • *Quadratic functions* • *Simple rational functions* • *Exponential functions* • *Absolute value functions*	Supporting

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HSA.CED.A.2	13	• Create equations in two or more variables to represent relationships between quantities • Graph equations, in two variables, on a coordinate plane.	Major
HSA.CED.A.3	13	• Represent and interpret constraints by equations or inequalities, and by systems of equations and/or inequalities. • Interpret solutions as viable or nonviable options in a modeling and/or real-world context.	Major
HSA.CED.A.4	13	Rearrange literal equations using the properties of equality	Major

Key:

ASM Domain and Standard #	ASM Cluster	ASM Standard	Course Emphases (Category)

Domain: Reasoning with Equations and Inequalities
Cluster(s): 14. Understand solving equations as a process of reasoning and explain the reasoning
15. Solve equations and inequalities in one variable
16. Solve systems of equations and inequalities graphically.
17. Solve systems of equations

HSA.REI.A.1	14	Assuming that equations have a solution, construct a solution and justify the reasoning used. Note: Students are not required to use only one procedure to solve problems nor are they required to show each step of the process. Students should be able to justify their solution in their own words.	Major
HSA.REI.A.2	14	Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise. *For example: The area of a square equals 49 square inches. The length of the side is 7 inches. Although -7 is a solution to the equation, $x^2 = 49$, -7 is an extraneous solution.*	Major
HSA.REI.B.4	15	Solve quadratic equations in one variable. • Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x - p)^2 = q$ that has the same solutions. Note: This would be a good opportunity to demonstrate/explore how the quadratic formula is derived. This standard also connects to the transformations of functions and identifying key features of a graph (F-BF3). Introduce this with a leading coefficient of 1 in Algebra I. Finish mastery in Algebra II. • Solve quadratic equations (as appropriate to the initial form of the equation) by: o Inspection of a graph o Taking square roots o Completing the square o Using the quadratic formula o Factoring Recognize complex solutions and write them as $a \pm bi$ for real numbers a and b.	Supporting
HSA.REI.C.5	16	• Solve systems of equations in two variables using substitution and elimination.	

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		• Understand that the solution to a system of equations will be the same when using substitution and elimination.	
HSA.REI.C.6	16	Solve systems of equations algebraically and graphically.	Major
HSA.REI.C.7	16	Solve systems of equations consisting of linear equations and nonlinear equations in two variables algebraically and graphically. *For example: Find the points of intersection between $y = -3x$ and $y = x^2 + 2$.*	Additional
HSA.REI.C.8	16	(+) Represent a system of linear equations as a single matrix equation in a vector variable.	Supporting
HSA.REI.C.9	16	(+) Find the inverse of a matrix if it exists and use it to solve systems of linear equations (using technology for matrices of dimension 3 × 3 or greater).	Supporting
HSA.REI.D.11	17	Explain why the x-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; Find the solutions approximately by • Using technology to graph the functions • Making tables of values • Finding successive approximations Include cases (but not limited to) where $f(x)$ and/or $g(x)$ are • Linear • Polynomial • Rational • Exponential (Introduction in Algebra 1, Mastery in Algebra 2) • Logarithmic functions Teacher notes: Modeling should be applied throughout this standard.	Major
HSA.REI.D.12	17	Solve linear inequalities and systems of linear inequalities in two variables by graphing.	Major

Domain: Interpreting Functions
Cluster(s): 18. Understand the concept of a function and use function notation

Key:

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19. Interpret functions that arise in applications in terms of the context
20. Analyze functions using different representations

HSF.IF.A.3	18	Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. *For example: The Fibonacci sequence is defined recursively by* $f(0) = f(1) = 1$, $f(n+1) = f(n) + (n-1)$ *for* $n \geq 1$.	Supporting
HSF.IF.B.4	19	For a function that models a relationship between two quantities: • Interpret key features of graphs and tables in terms of the quantities, and • Sketch graphs showing key features given a verbal description of the relationship. Note: Key features may include but not limited to: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.	Major
HSF.IF.B.6	19	• Calculate and interpret the average rate of change of a function (presented algebraically or as a table) over a specified interval. • Estimate the rate of change from a graph.	Major
HSF.IF.C.7	20	Graph functions expressed algebraically and show key features of the graph, with and without technology. • Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior. • (+) Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior. • Graph exponential and logarithmic functions, showing intercepts and end behavior. • (+) Graph trigonometric functions, showing period, midline, and amplitude.	Supporting
HSF.IF.C.8	20	Write expressions for functions in different but equivalent forms to reveal key features of the function. • Use the properties of exponents to interpret expressions for exponential functions. Note: Connection to A.SSE.B.3c Note: Various forms of exponentials might include representing the base as $1 \pm r$, where r is the rate of growth or decay.	Supporting

Domain: Building Functions

Key:

ASM Domain and Standard #	ASM Cluster	ASM Standard	Course Emphases (Category)

Cluster(s): 21. Build a function that models a relationship between two quantities
22. Build new functions from existing functions

HSF.BF.A.1	21	Write a function that describes a relationship between two quantities. • From a context, determine an explicit expression, a recursive process, or steps for calculation. • Combine standard function types using arithmetic operations. *(e.g., given that f(x) and g(x) are functions developed from a context, find (f + g)(x), (f – g)(x), (fg)(x), (f/g)(x), and any combination thereof, given* $g(x) \neq 0$*.)* • Compose functions.	Major
HSF.BF.A.2	21	• Write arithmetic and geometric sequences both recursively and with an explicit formula, and translate between the two forms. • Use arithmetic and geometric sequences to model situations	Major
HSF.BF.B.3	22	• Identify the effect on the graph of replacing $f(x)$ *by* $f(x) + k, k f(x), f(kx),$ and $f(x + k)$ for specific values of k (k, a constant both positive and negative); • Find the value of k given the graphs of the transformed functions. • Experiment with multiple transformations and illustrate an explanation of the effects on the graph with or without technology. *Include recognizing even and odd functions from their graphs and algebraic expressions for them.*	Additional
HSF.BF.B.4	22	Find inverse functions. • Solve an equation of the form $y = f(x)$ for a simple function f that has an inverse and write an expression for the inverse. *For example,* $f(x) = 2x^3$ *or* $(x) = (x + 1)/(x - 1)$ *for* $x \neq 1$. • Verify by composition that one function is the inverse of another. (Algebra II) • Read values of an inverse function from a graph or a table, given that the function has an inverse. (Algebra II) • (+) Produce an invertible function from a non-invertible function by restricting the domain.	Additional
HSF.IF.B.5	22	• Relate the domain of a function to its graph. • Relate the domain of a function to the quantitative relationship it describes. *For example: If the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.*	Major

Key:

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Domain: Linear, Quadratic, and Exponential Models
Cluster(s): 23. Construct and compare linear, quadratic, and exponential models and solve problems

HSF.LE.A.2	23	Construct linear and exponential equations, including arithmetic and geometric sequences, • given a graph, • a description of a relationship, or • two input-output pairs (include reading these from a table).	Supporting
HSF.LE.A.4	23	• Express exponential models as logarithms • Express logarithmic models as exponentials • Use properties of logarithms to simplify and evaluate logarithmic expressions (expanding and/or condensing logarithms as appropriate) • Evaluate logarithms with or without technology Note: For exponential models, express the solution to $ab^{ct} = d$ where *a*, *c*, and *d* are constants and *b* is the base (Including, but not limited to: 2, 10, or *e*) as a logarithm; then evaluate the logarithm with or without technology. Connection to F.BF.B.5	Supporting

Key:

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Domain: Interpreting Categorical and Quantitative Data
Cluster(s): 24. Summarize, represent, and interpret data on a single count or measurement variable
25. Make inferences and justify conclusions from sample surveys, experiments and observational studies

HSS.ID.A.4	24	• Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. • Recognize that there are data sets for which such a procedure is not appropriate. • Use calculators and/or spreadsheets to estimate areas under the normal curve. Note: Limit area under the curve to the empirical rule. (68-95-99.7) to estimate the percent of a normal population that falls within 1, 2, or 3 standard deviations of the mean. Also, recognize that normal distributions are only appropriate for unimodal and symmetric shapes.	Additional
HSS.ID.B.6	25	Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. • Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Note: Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models. The focus of Algebra I should be on linear and exponential models while the focus of Algebra II is more on quadratic and exponential models.	Supporting

Key:

ASM Domain and Standard #	ASM Cluster	ASM Standard	Course Emphases (Category)

Domain: Making Inferences and Justifying Conclusions

Cluster(s): 26. Understand and evaluate random processes underlying statistical experiments

27. Make inferences and justify conclusions from sample surveys, experiments and observational studies

HSS.IC.A.1	26	Recognize statistics as a process for making inferences about population parameters based on a random sample from that population.	Supporting
HSS.IC.A.2	26	Compare theoretical and empirical probabilities using simulations (e.g. such as flipping a coin, rolling a number cube, spinning a spinner, and technology).	Supporting
HSS.IC.B.3	27	• Recognize the purposes of and differences among sample surveys, experiments, and observational studies • Explain how randomization relates to sample surveys, experiments, and observational studies	Major
HSS.IC.B.6	27	Read and explain, in context, the validity of data from outside reports by • Identifying the variables as quantitative or categorical. • Describing how the data was collected. • Indicating any potential biases or flaws. • Identifying inferences the author of the report made from sample data. Note: As a strategy, students could collect reports published in the media and ask students to consider the source of the data, the design of the study, and the way the data are analyzed and displayed.	Major

Key:

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